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MONITORING FISH BEHAVIOUR AND ENTRAPMENT AT THE DARLINGTON NGS COOLING WATER INTAKE

Report No 91-82-K

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ABSTRACT

To assess the design effectiveness of the Darlington PPB intake at reducing fish entrapment and impingement, three video systems and a scanning sonar were tested and evaluated. The submersible (ROV) provided a mobile and stationary means of patrolling the intake surface and periphery, and exploring the forebay and tunnel exit. Although few fish were observed near the intake surface, shiners, sculpins, alewife, and smelt were video recorded in the forebay. A housed stationary camera was secured to the porous modules on four occasions. The video records revealed the presence of many alewife and smelt swimming about, oblivious to the camera's presence. A scuba diver swam about the intake with a housed camcorder. Schools of predominantly juvenile alewife were recorded and approached to within 2 m. Air exhaust bubbles caused a momentary frightened response and the fish appeared wary of the diver's presence. The scanning sonar malfunctioned early during testing and consequently, very little useful results were obtained. A high resolution sonar system is currently being developed and tested. Greatly improved estimates of fish distribution and abundance are expected. As a result of station commissioning delays, negligible current flow passed through the intake. Sculpins were observed swimming easily in and out of the porous modules. Low velocity service water currents entered the forebay. Fish congregated around the tunnel exit perhaps as opportunistic feeders. Fish response over the intake slots can best be observed by video means rather than sonar. Light and turbidity greatly affected video quality, however. A combination of video and sonar systems may provide the overall best results. Evaluation cannot be completed until the station becomes operational. Success of the design can then be assessed.

job	34-149-090	file	837.321 DAR	date	April 10, 1991	report no.	91-82-K
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EXECUTIVE SUMMARY

MONITORING FISH BEHAVIOUR AND ENTRAPMENT AT THE DARLINGTON NGS COOLING WATER INTAKE

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Biological Research Section

This study was performed as part of the Darlington NGS commissioning and post-operational environmental assessment studies. The objective was to evaluate the effectiveness of the precast porous bottom (PPB) intake design at reducing fish losses due to impingement. Excessive depletion of fish stock may produce deleterious effects on fish populations. Heavy fish impingement has also resulted in structural damage to pumphouse debris screens and caused cooling water loss resulting in reduced generation at some stations.

Three video systems and a scanning sonar were tested. The equipment was operated from a vessel moored over the intake surface. Video monitoring consisted of a mobile submersible (ROV), a stationary camera enclosed in a submersible housing and a diver operated housed camcorder. Video records were stored on cassette tape. A tower resting on the intake centre piece supported the sonar transducer three metres above the intake surface. A video camera recorded the sonar trace and echoes produced from the onboard transceiver screen.

The ROV was used to patrol the intake surface seeking fish encounters and was also parked in a stationary monitoring position. The ROV was deployed over the intake on three occasions during September, 1987 and on seven occasions from August to October, 1988. Ten sculpins, 10 yellow perch, 3 white suckers, 3 alewife and 1 possible gizzard shad or freshwater drum were observed from fourteen hours of video recordings.

The ROV submersible was also used to explore the forebay channel and tunnel exit to determine possible fish residency and entrapment. Eight sculpins and 2 alewife were observed near the exit during 1.5 hours of video recording made in November, 1987. In mid-September, 1988, eight hours of video were recorded over four days. Twelve sculpins, 1 alewife and 1 dead white sucker were seen in the channel; 170 shiners, 76 sculpins, 16 smelt, 13 alewife, 1 rock bass and 1 unidentified species were counted at the tunnel exit.

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The stationary camera was positioned once on the intake in early November, 1987; no fish were observed. In July and August, 1988, 7.5 hours of video were recorded. Approximately 773 alewife, 414 smelt, 11 sculpins, 3 white suckers and 1 unidentified fish were counted. The alewife passed by the camera either as schools or as individuals.

A diver swam about the intake holding the camcorder on four dates in June, 1988. Schools of yearling alewife (>100 individuals) were occasionally observed; among these were a few adults and possible smelt. Nine sculpins were also recorded swimming over the porous modules. In early July, a night dive was performed using a submersible light. The diver observed many individual yearling alewife and smelt near the intake surface. A flooded housing destroyed the video record.

The scanning sonar was tested early in November, 1987 and June, 1988 on three occasions. No targets were observed and the echo trace was of insufficient brilliance and clarity to provide a good video record. The sonar system malfunctioned and further testing of the system was discontinued.

Video systems permitted effective observation of fish behaviour and most fish could be identified and counted. Video effectiveness was greatly influenced by available light and turbidity. Artificial lights were necessary for night observations or at the tunnel exit into the forebay where depths exceeded sunlight penetration. Lights may have affected fish behaviour by attraction or avoidance.

The ROV was deployed both actively and stationary. It did not appear to influence fish behaviour. The ROV effectively explored the forebay although its usefulness may be reduced as current velocities increase with unit commissioning. The ROV could also be operated for several hours at a time. Caution must be exercised when operating over silt, rocks and ledges or around debris and obstructions.

The stationary camera did not appear to influence fish behaviour. It could be operated for extended periods with minimal attention. It was limited to viewing a small area from a fixed position and was reliant upon chance encounters by fish.

A diver could view a wide perspective and focus the camcorder on selective subjects. The diver's personal observations also supplemented the video record. Bubbles from the diver's air exhaust appeared to startle schooling alewife and caused an avoidance response. Depth, bottom time and safety considerations limited the use of divers. Divers were also restricted from the forebay.

The sonar system was not affected by the absence of light nor high turbidity. It could survey a large volume of water for an extended period. Sonar was useful for detecting fish distribution and estimating relative abundance around the intake structure. It may also become the only means possible for use in the forebay as currents exceed the capacity of the ROV. It is unlikely that sonar can observe actual fish response to the PPB intake currents. This may be described better

by video techniques. The sonar system used in the present study is to be replaced by a high resolution sonar system currently under development.

Commissioning and operation of the CCW pumps was delayed throughout 1987-1988. As a result, negligible currents were observed at the intake during the testing period and only low velocity service water currents were present in the forebay. Video and diver observations successfully revealed the presence of fish (predominantly alewife) in close proximity (within 3m) of the intake surface. Until substantial intake currents are created, fish response to the PPB intake structure cannot be described and an evaluation of the effectiveness of the intake design at reducing impingement cannot be completed. Station impingement records combined with sonar relative abundance estimates may ultimately determine the success or failure of the PPB intake.

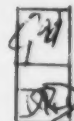


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**MONITORING FISH BEHAVIOUR AND ENTRAPMENT
AT THE DARLINGTON NGS COOLING WATER INTAKE**

1.0 INTRODUCTION

Ontario Hydro has a responsibility to minimize its impact on the local environment during both its construction and operational phases of electrical power generating stations. Possible entrainment and subsequent entrapment of fish species in cooling water (CW) intakes of these generating stations is of principal concern both environmentally and mechanically. Entrapped fish eventually end up exhausted or dead on pump house screens; in large numbers, fish clog the screens causing mechanical damage and CW head loss. This may result in reduced generated power output or complete shut-down of the station (OHRDR No 77-400-K). As part of a pre-operational and post-operational environmental assessment review of the Darlington GS as described by Maher, 1984 (ESADR No 84252), this study was initiated to evaluate the effectiveness of the intake design in reducing fish losses due to impingement.

At the Darlington Nuclear Generating Site, a concrete, precast porous bottom (PPB) cooling water intake has been designed and constructed to address environmental concerns as well as to provide 4-unit (151 m³) flow requirements for condenser cooling water (CCW) and service water (SW). In general, the intake structure follows a modular design concept consisting of three principal components; a single centre piece unit, 60 non-porous modules and 124 porous modules (Figure 1). During construction, each module was lowered from the lake surface to its position on the bottom and any unit can be removed if damaged. The centre piece measures approximately 16.5x16.5m (272m²); each non-porous and porous module is approximately 5.4 x 5.4m (29.2m²) and is separated from adjacent modules by a 0.1m space and rubber bumper. Through the top of each porous module are 16 parallel, smooth concrete slot openings 140 mm x 4699 mm. Typical slot beam widths are 156mm. The slots perform the dual function of providing entrance for cooling water into the intake at a low velocity (~15 cm/s, range: 5 - 30 cm/s) which most juvenile and mature fish can escape and providing a surface structure (ie slot beams) which entrained fish can "shadow" into and escape the stronger currents. Steel rods (20mm dia) lie over the slots at right angles, creating individual openings ~14x15cm. The entire structure is approximately 3 m in height; the top surface or roof of the intake lies a minimum of 10 m below mean monthly lake water level and is roughly 0.5 m above lake bottom grade.

1. Centre piece
2. Non-porous module
3. Standard porous module
4. Peripheral corner module
5. Peripheral wall module

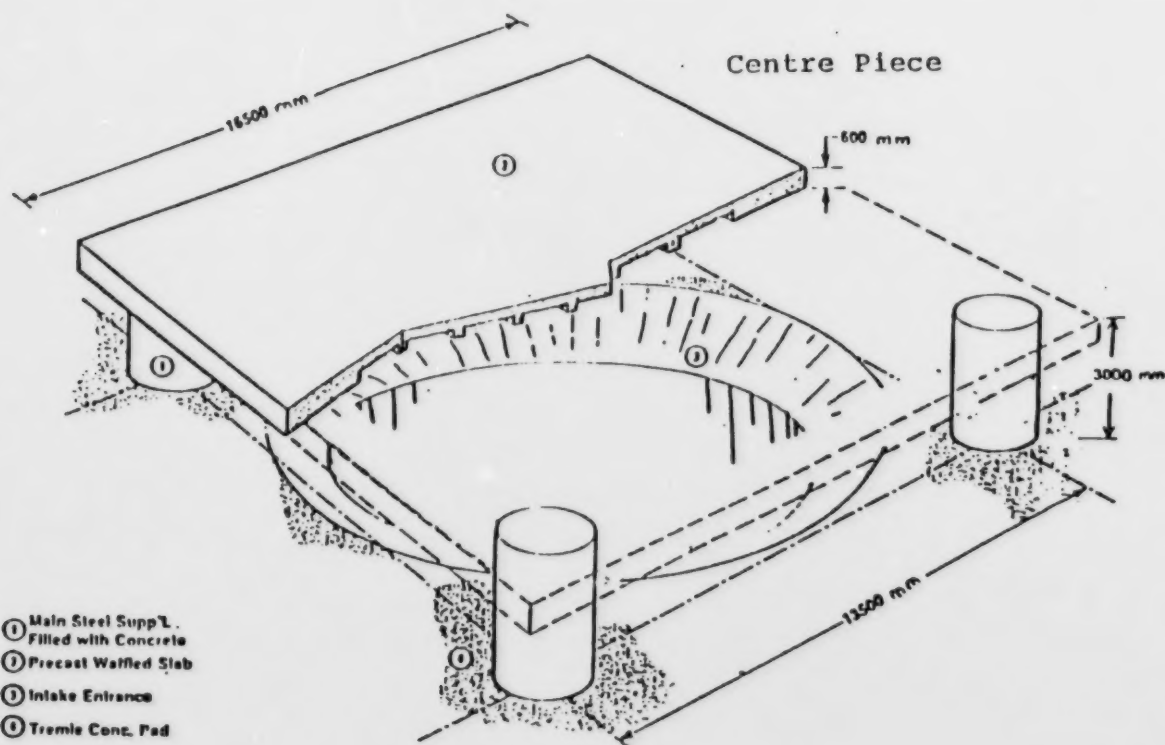


FIGURE 1

PERSPECTIVE VIEWS OF OVERALL INTAKE
STRUCTURE AND CENTRE PIECE

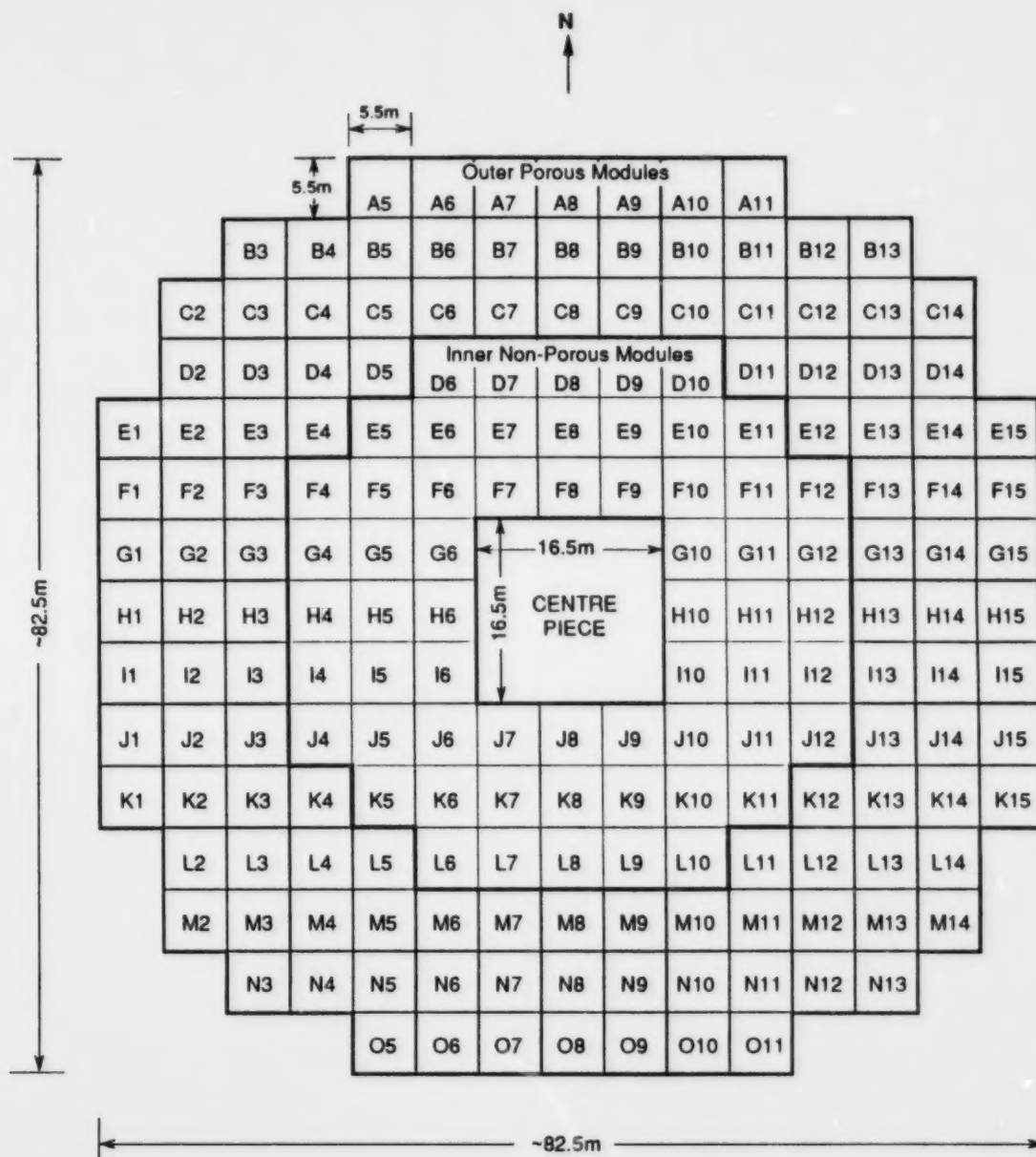


FIGURE 2
DARLINGTON NGS INTAKE SURFACE STRUCTURE

The centre piece is positioned directly over the intake shaft which leads to the excavated intake tunnel. The modules are arranged in rows and columns around the centre piece, the porous modules positioned toward the periphery (Figure 2). The arrangement of the modules is designed to prevent vortices forming on the lake water surface.

Prior to construction of the PPB intake structure, Ontario Hydro's Flow Systems Laboratory tested a 1:20 scale model. The resultant hydraulic characteristics are provided in OHDDR No 84-237. In general, simulated operational flow velocities proximal to the porous modules remained below 30 cm/s. Until station operation begins these measurements cannot be validated. It was expected that CW pump tests would begin in August, 1987 and would be operated intermittently, varying from 10 to 31.5 m³/s (up to 20% of design flow, ie. 151 m³/s). Actual commissioning of Unit 2 was to begin in late fall or early winter, 1988. To assess the effectiveness of the PPB intake in excluding and subsequently entrapping fish species during commissioning and operational years (during two-unit and four-unit operation), it was necessary to observe fish species, abundance, size, age group, and behavioural response to the structure. Although pump-house trash bin counts provide useful supplementary data on entrapment mortality, they do not answer questions as to: the duration of fish residency in the forebay; diurnal variation of impingement; daily/weekly variation of impingement; and, whether fish avoid, choose to enter or escape from the intake. It was possible that fish may congregate over the PPB intake surface as opportunistic feeders utilizing the intake currents as an efficient means to catch prey.

To observe fish, video and sonar systems were tested over the PPB intake surface. They included a mobile submersible (ROV), a stationary housed low-light video camera, a diver equipped with a housed camcorder and a scanning sonar. The ROV was also operated in the forebay. Initial testing began on September 10 and continued until November 27, 1987, resuming the following year from June 8 to October 6.

2.0 METHODS

2.1 Mobile Submersible

A remotely operated submersible vehicle (ROV) was purchased from Sea-scan Technology of Calgary, Alberta. It came equipped with a modified JVC colour video camera and a wide angle Cosimic lens. Orientation was achieved using a digital compass heading sensor, digital depth sensor and dual 250 W navigational lights (minimum illumination was 500 lux). Twin DC powered horizontal and vertical thrusters each provide, 6.9 kg of propulsion; maximum surface speed was 1.3 m/s (2.5 knots). The vehicle was tethered to a surface vessel by a signal cable and polypropylene line. Visual orientation was provided to the operator by a colour video monitor and the ROV is manoeuvred by means of a joy-stick hand controller. The ROV can be directed in all attitudes. Once submerged, navigation was accomplished utilizing a combination of the depth and compass indicators and by visual orientation to recognizable landmarks or bottom features. On silty substrate and in the absence of currents, the ROV must be moved about slowly and carefully to avoid silt being mixed into the water by the thrusters. Increased turbidity may

cause a loss of orientation. Moving slowly also reduced compass indicator roll; iron and steel also appeared to influence compass rotation. Moving about slowly was also less likely to disturb fish. Observations were retained on a JVC-VHS video cassette recorder for later review and analysis.

The submersible was operated both actively and passively over the intake surface. Actively, the ROV "patrolled" over porous and non-porous modules and the surrounding lake bottom; passively, the ROV was "parked" viewing across the intake surface.

To determine possible fish residence within the forebay prior to CW pump tests, the ROV was used to survey the channel bottom from the east end to the tunnel exit. As the station becomes increasingly operational, currents, turbulence and velocity may inhibit the effective use of the ROV in the forebay.

2.2 Stationary Video

During daylight, a low-light, black and white RCA video camera model TC 1030H26, supplied with a Fujinon CF8A auto-iris lens and enclosed in a submersible housing was lowered onto the PPB intake surface. Divers positioned the housing on a peripheral porous module, secured it and adjusted the viewing angle inward over the intake surface. A cable carried the video signal to an Electrohome monitor and JVC-VHS video cassette recorder on board the vessel at the surface. Power was supplied by a portable, gasoline Honda generator, Model 3500X. Porous module positions were each identified by row and column. Initial mechanical problems with the RCA camera resulted in its replacement with a Panasonic low-light black and white video camera, model WV-1354 equipped with a Cosmimar auto-iris lens, KF-85A. Videotapes were later reviewed for fish species composition, abundance and behavioural patterns.

2.3 Diver/Camcorder

To supplement stationary and mobile video systems, a diver equipped with a compact Sony camcorder, model CCD-M8 enclosed in a submersible housing, swam about over the PPB intake surface. This method tested and recorded fish response to an observer (diver) present in the water. The diver was able to orient himself over the intake, identify his position and note landmarks. Observations of fish species, their behaviour, direction of movement, response to intake currents and areas of encounters were noted and recorded on 8 mm videotape. Species identification and density estimates by the diver, enhanced the video record. Dives were made during daylight when visibility was at least 2m; one night dive was planned using an Ikelite videolite to provide lighting for the camera. Light may attract some fish but frighten others. Under darkness, depth of view was not expected to exceed 2m. Observations of change in species composition and behavioral response to intake currents and to the diver were noted. During a dive, the diver made observations of current velocity around various porous modules by feel and by watching the drift of suspended particles. Direction of lake currents were noted.

2.4 Scanning Sonar

Video and diver observations of fish were limited to less than 5m due to low light and turbidity. A Wesmar scanning sonar, model SS 150, was tested at the PPB intake. Qualitative information was collected by acoustically detecting fish schools and large individuals moving over the intake. Depth and directional approach and departure to the intake was noted.

A tripod tower was constructed by the Darlington NGS machine shop to support the sonar transducer. The tower was lowered 11m from a surface vessel and placed on the centre of the intake, approximately 41m from the periphery. Divers mounted the transducer 3m above the centre piece. The control and signal cable was connected to the onboard sonar transceiver console. When not in use, the cable was disconnected from the console, sealed from the weather and secured to a mooring buoy over the intake. DC power was supplied to the console by two, deep-cycle, 12 volt batteries connected in series (24 V). The transducer was operated in the horizontal tilt position and set to scan up to 61m (200ft). The 7° sound beam was adjusted to automatically sweep 30° to 360° or be directionally positioned to scan desired areas of the intake. The approximate height of the scan at the periphery was 5m. A portable Phillips VHS camcorder set to macro-focus, videotaped the image produced on the sonar CRT screen for subsequent review.

3.0 RESULTS AND DISCUSSION

CW pump tests were delayed from August, 1987 to later in the fall and subsequently further delayed throughout 1988; Unit 2 ultimately went critical November 5, 1989 and reached full capacity in summer, 1990. During these tests, service water required for station operation, produced low velocity currents in the forebay as well as exiting from the diffuser ports. No noticeable current was evident around the intake modules, with the exception of lake currents, throughout the entire study period. Despite the absence of intake currents, testing of the monitoring methods provided useful preliminary information with respect to logistical problems and limitations of the equipment and the working environment. Observations were made and are discussed.

3.1 Mobile Submersible

3.1.1 PPB Intake

During 1987, the submersible was deployed over the PPB intake surface on three occasions (September 10, 15 and 16). About 3 hours and 20 minutes (3:20) of videotape was recorded from intake observations. Visibility was estimated at 3 m. One white sucker and two sculpins were seen on September 10; no fish were observed on September 15 or September 16. The sucker slowly swam away from the ROV and did not appear disturbed; the sculpins intermittently swam a short distance, rested on the concrete, then swam a short distance once more. The sculpins were approached to within a few centimetres without disturbance.

A video record using the ROV on the intake surface was made on seven occasions from August 16 to October 6, 1988. The ROV was used to explore the intake surface and peripheral areas as well as to monitor stationary, viewing across the slots. From 10.5 hours of video tape of the intake, only 8 sculpins, 3 alewife, 10 yellow perch, 2 white suckers and 1 possible gizzard shad or freshwater drum were seen. Bottom temperature ranged from 7.1°C to 20.2°C and visibility was 2-3 m; no current was apparent. Fish that were seen did not appear alarmed by the ROV.

3.1.2 Forebay

On two occasions during 1987, the ROV was used to explore the forebay. About 1.5 hours of video was recorded on November 24. Two alewife, 8 sculpins and a few crayfish were seen within the tunnel exit. The sculpins tended to rest on the bottom or seek shelter beneath rocks on the ledge; the alewife were free swimming. A fuse blew in the vertical starboard thruster during descent on November 27. Control of the vehicle was too difficult to manoeuvre safely and operation was discontinued until next season. The ROV's lights were used for navigation since sunlight did not penetrate to the bottom of the tunnel exit, a depth of 32 metres. A considerable amount of soft sediment has become deposited on the tunnel floor. This was easily stirred up by the ROV thrusters, obscuring visibility. When the ROV was operated along the bottom, tracks from the skids were left in the silt. Current velocity was estimated to be less than 1 m/s. Considerable debris left over from construction, lay on the bottom. Sharp rocks and pieces of chain link cribbing threatened entanglement of the ROV and its tether.

The submersible explored from the east end of the forebay channel to the tunnel exit on four occasions between September 14 to 23, 1988. A total of 8 hours of video was recorded. Excluding the tunnel exit, 12 sculpins, a possible alewife and 1 dead white sucker were observed. The greatest concentration of fish observed in the forebay was within the tunnel or around the periphery of the tunnel exit. A total of 277 fish and several crayfish were counted from the video record; 170 shiners and 76 sculpins represented 89% of the fish sightings. Others were 16 smelt, 13 alewife, 1 rock bass and 1 unidentified fish. It is possible that many of these fish may have been counted more than once as fish tended to inhabit the area about the tunnel exit and close to the bottom. Fish moved upstream and downstream in the current passing in and out of camera view. Fish did not appear greatly disturbed by the ROV. However, observations seemed to suggest some disorientation by smelt and alewife due to the ROV lights reflecting off the tunnel walls. Considerable suspended material drifted downstream in the current. Turbidity and the absence of sunlight restricted viewing to less than 2m. It is possible that "shy" fish remained out of view of the camera and consequently were not identified and recorded. Possibly, fish occupied the tunnel exit as opportunistic feeders on zooplankton or prey that drifted by. Fish presence along the entire tunnel length was not determined. The ROV was probably not operated greater than 10 m into the tunnel from the exit into the forebay.

3.2 Stationary Video Camera

On November 6, 1987, the surface crew lowered the RCA video camera and housing on to the south-west area of the intake structure. Divers secured the housing to a porous module. Problems

soon arose with the auto-iris lens stopping down, reducing sufficient light for a video picture. Examination of the camera at the surface indicated that a loose connection was present within the lens; only a light tapping or movement of the camera caused the lens to open or close. In addition, rolling "noise" lines across the video monitor screen, possibly caused by the generator, resulted in a poor quality video picture. During brief periods when the camera was functioning on the bottom, no fish were observed from the video or by the diver.

On July 28, 1988, the RCA camera was replaced with a Panasonic model. The camera was positioned on a north-west peripheral porous module, C3 and viewed inward over the slots for two hours. Bottom temperature was 15°C; visibility was 2 m and no currents were reported by the diver. From the video record, schools of alewife (50-100) and a few smelt (<50) were milling about or slowly schooling past the camera. More fish appeared to pass from offshore toward onshore; however, since the field of view is shallow and narrow, it may be possible the fish were swimming in a circle. Review of the alewife behaviour, seemed to suggest that the fish may be feeding, using an upward, snapping motion possibly selecting zooplankton. At no time did any fish seem disturbed by the presence of the camera. On more than one occasion, a fish made contact with the lens face of the camera housing.

On August 3, the camera was set up to view north-east over intake porous module N3, located on the south-west periphery of the intake. Two hours of video were recorded. As on July 28, schools of alewife passed by the camera, generally from east to west. Fish counted were 483 alewife, 245 smelt and 1 sculpin. Water temperature was 16°C - 18°C; visibility was 2 m and a noticeable lake current flowed from east to west. In general, the schooling fish moved with the direction of current flow. On August 10, the camera was positioned on N12, a porous module located south-east on the intake. Viewing north-west, 141 alewife, 60 smelt, 7 sculpins, 2 white suckers and 1 unidentified fish were counted from the two-hour video tape record. No significant intake current was apparent as the sculpins were able to swim freely in and out of the slots. Bottom temperature was 10°C and visibility was 2.5 to 3 m.

On August 11, the camera was moved to the north-east periphery, viewing south-west over porous module C11. Bottom temperature increased to 12°C. An hour and a half of video tape was recorded; from this, 74 alewife, 59 smelt, 3 sculpins and 1 white sucker were counted. The sucker passed from west to east swimming a few centimetres from the intake surface.

3.3 Diver/Camcorder

A diver descended to the PPB intake surface with the Sony camcorder on June 8, 1988 to videotape any fish present. The camcorder provided versatility by recording subjects the diver focused on. The diver had a wider perspective compared to the ROV and stationary video camera and could visually survey a greater area. The diver was also able to peer between the slots or focus on smaller objects. Visibility was about 3.5 m and water temperature was 6-7°C. No intake current was evident; a *Mysis* was able to swim freely over an intake slot and a dead alewife lying on the steel grating covering the porous modules was not disturbed by currents. Four sculpins also swam about freely over the intake and could easily be approached and prodded by the diver.

A large school (100+ individuals) of predominantly juvenile (yearlings) alewife swam over the south-west area of the intake. Adult alewife and possibly young smelt also mixed with the school. The fish were wary of the diver and were startled by exhaust bubbles. The school was often approached to within 2-3 m; the diver swam along with the school to keep the fish in view. Initially, turning on an underwater diver's light alarmed the fish. However, they soon became accustomed to the light. It was felt that many more fish were present as the school disappeared into the turbid water. On occasion, when the diver rested on the bottom, alewife passed by the peripheral limits of visibility but soon disappeared each time the diver exhaled.

The camcorder was also used to monitor fish near the intake surface on four other occasions. On June 16, only 1 live alewife was seen. On June 23, 4 sculpins were observed and a few schools of juvenile alewife numbering 50-100 individuals each, swam 1-3 m above the west intake modules. Some adult alewife swam with the school. On June 29, one sculpin was seen swimming over south-east porous modules. Only a strong westward flowing lake current was evident. On July 6, a night dive with the camcorder was made. However, the underwater housing flooded through the microphone seal and the video record was destroyed. The camera was subsequently sent for repair. The diver reported seeing juvenile smelt and alewife. The fish often swam up to the diver's light and bounced off the lens. A water-tight floodlight was prepared for use with the stationary camera under darkness. However, an opportunity to test this approach did not arise.

3.4 Scanning Sonar

The sonar transducer was initially mounted to the tower on October 6, 1987, the sound-dome positioned about 3 m above the intake surface. The sonar system was tested for an hour on November 6, 1987 before weather deteriorated. No targets were observed.

Testing continued on November 12; a Phillips VHS camcorder was used on macro focus to videotape the image produced on the CRT screen. It was found that the trace was of insufficient brightness to provide a good video record. At full brightness, the echo trace becomes heavier and may obscure small targets. After less than an hour of testing, the trace disappeared perhaps as a result of reduced battery power due to cold and energy consumption. No targets had been detected which was not surprising since few fish were taken in recent overnight gill net sets in the area. Weather and other commitments did not permit further use of the sonar until the following season. The transducer was removed from the water in mid-December.

On June 1, 1988 the sonar transducer was remounted on the submerged tower resting on the intake centre piece. The system was connected the following day and tested. No signal trace appeared on the CRT screen. The unit was submitted to the Research Instrument Repair unit to diagnose the problem. The console unit tested functional and a signal was being transmitted. The fault was traced to the transducer within the sound-dome. Unfortunately, the dome is a sealed unit and cannot be removed without damage. When this was discussed with Wesmar in Seattle, it was learned that the unit would have to be returned to them to remove the sound-dome. They were not certain that they had a replacement since the 150 model had been out of production for some time and was considered obsolete by today's state-of-the-art scanning sonar.

Instrument Repair also pointed out, that the pins in the rear of the CRT were loose and quite fragile and the longevity of the tube was questionable. It was decided to shelve the sonar for the time being. A more sophisticated remote sensing, and fixed array hydroacoustic system is currently being developed by the Biological Research Section. Testing at the Darlington intake is planned for summer and fall, 1990.

4.0 CONCLUSIONS

Despite the absence of flow around the PPB intake surface owing to Darlington station delays, several methods for assessing fish response were field tested. Logistical problems and equipment limitations were recognized. A quick reference listing advantages and disadvantages of each system is provided for comparison in the Appendices. As each piece of equipment has some advantage over another, the most thorough gathering of information might utilize combinations. The limitations, restrictions, time and cost effectiveness must be considered. It is also possible that as the plant becomes increasingly operational the methods explored may no longer be practical. This is particularly so with respect to the forebay where currents and turbulence will exceed the rated capacity of the ROV; sonar and impingement records may be the only means of collecting data in the forebay.

Fish species were identified and abundance estimated around the intake surface and in the forebay. Alewife, smelt and shiners were present in notable numbers; alewife represented the numerically dominant species. Other species observed were sculpin, white sucker, yellow perch, rock bass and freshwater drum or gizzard shad. Under low velocity currents (<1.3 m/s), the ROV provided a useful means of monitoring in the forebay. The tunnel exit is too deep (32 m) for diver safety; placement of a stationary video camera would be difficult due to currents and the risk of snagging the cable on rocks or loose chain link cribbing; sonar was not evaluated in the forebay. The submersible has the advantage of mobility as well as remaining stationary. When the ROV is "parked" and intake currents are present, the use of thrusters may be necessary to maintain position. This may disturb fish and/or suspend sediment and increase turbidity. Although it is not conclusive that the ROV does not influence fish behaviour, it is less likely to do so than the presence of a diver. Deployment of the submersible does not require servicing by a diver team; it can be operated for considerable time and in deep water during daylight or in darkness (using lights).

Stationary video camera appears to present no disturbance to fish species and can best be used to evaluate response to intake currents. Owing to its limited coverage, successful use is dependent upon chance encounters and periods of an abundance of fish. This can partially be overcome by lengthy monitoring; however, this further intensifies the laborious task of reviewing the videotapes. Positioning the camera was required by diver although it may be possible to heavily weight the housing rather than anchor it to the intake. Adjusting the viewing angle and orienting placement may prove difficult without diver assistance. Use is also restricted to periods of low turbidity and daylight operation. Artificial lighting may enhance the video record but, it remains uncertain how this may influence fish behaviour. Some species may be attracted while

others are disoriented or dispersed. The importance of determining fish behaviour around the intake during darkness should not be overlooked; early studies of alewife at Pickering NGS suggest that entrapment is consistently higher at night than by day (OHRDR No 78-77-K). The relationship between entrapment and station impingement records is complicated by unknown residency within the tunnel and forebay network as well as by fluctuations in plant pumping operations or dramatic lake water temperature changes (seiche effects/lake upwellings).

A diver has a greater depth of field than a camera and can select subject material to videotape; the diver can supplement the video record with his own observations. A diver is able to peer into the slots and other crevices where fish may hide or seek shelter. A diver may recognize small fish, eggs or larval forms beyond the resolution of video cameras. A diver is able to orient using intake features and landmarks and read identification plates on the modules. Observations made by divers suggest that air exhaust bubbles from breathing appear to frighten some fish (eg. alewife). Accordingly, this may reduce the effectiveness of assessing fish response to intake currents. Other fish such as sculpins do not appear to be disturbed by divers. Use of divers for monitoring is further disadvantaged by safety restrictions and limitations (depth, bottom time, crew size, cold etc.) and by cost effectiveness.

Regrettably, the Wesmar scanning sonar system malfunctioned without sufficient evaluation. It may have proved a qualitatively valuable means for detection of fish presence, relative abundance and for following their distribution over the peripheral areas of the intake. Results may identify specific areas or modules where fish species tend to localize or become entrained particularly during periods of heavy abundance. Sonar would therefore prove useful for identifying the most effective positioning of other means for observing fish response (eg, video; diver observations; gill netting). A major limitation by older sonar systems such as the Wesmar SS 150 is target resolution. Identification and differentiation of fish echoes close to the bottom (and subject to entrainment) is difficult and would require substantiation by video or visual means and/or netting. It is unlikely that behavioural response of fish in close proximity to the intake slots could be judged; it may be difficult to determine from sonar whether individuals entered the intake, were able to escape or sought refuge in areas of reduced flow over the slot beams. Schools of fish may be readily detected near the intake surface; however, their response to current flow would be somewhat conjectural without video or visual observation.

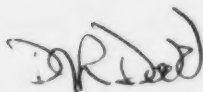
In order to assess fish residency and relative abundance within the forebay, it may be possible to mount transducers at various positions such as near the tunnel entrance or along the bar screens. Forebay data collected could be correlated with intake fish echoes and station impingement records. Sonar may provide the only means possible to effectively monitor fish density and distribution in the forebay as current velocity exceeds the capability of the ROV.

A major advantage of sonar over video systems is that operation is not affected by either turbidity nor the absence of light. Data can be collected over a continuous 24 hour period which is important to assess possible diurnal fish encounters and activity patterns over the intake surface. It may also be possible to transfer data through a modem to a remote data processing centre. This would reduce field costs as well as provide for future consideration as an early

warning system for activating fish intake exclusion devices. A considerable volume of water can also be surveyed in a relatively short interval.

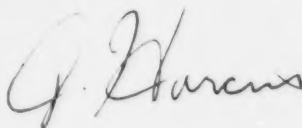
At present, Ontario Hydro Biological Research Section is developing a high resolution sonar system that will allow continuous collection of data. Resolution for targets has been greatly improved over the Wesmar SS150 and data is quantifiable. Resolution of the system has been estimated at approximately 10 cm (OHRDR 89-219-H) and recently below 5 cm under laboratory tests (Patrick, pers. com.). Estimating fish abundance in proximity to the intake and monitoring their movements on approach to the porous modules should be substantially improved.

Approved by:



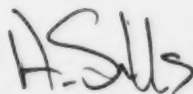
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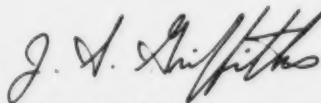


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APPENDIX 1

Numbers of Fish Observed by Video Above the PPB Intake (PPB) and in the Forebay (FB) (Submersible=ROV; Stationary Camera=SC; Camcorder=CC;)

Date	Location	Method	Fish Species							
			Alewife	Smelt	Sculpin	White Sucker	Rock Bass	Shiner	Yellow Perch	Unknown
10-09-87	PPB	ROV	0	0	2	1	0	0	0	0
15-09-87	PPB	ROV	0	0	0	0	0	0	0	0
16-09-87	PPB	ROV	0	0	0	0	0	0	0	0
24-11-87	FB	ROV	2	0	8	0	0	0	0	0
08-06-88	PPB	CC	>100	>50	4	0	0	0	0	0
16-06-88	PPB	CC	483	245	1	0	0	0	0	0
23-06-88	PPB	CC	141	60	7	2	0	0	0	0
28-07-88	PPB	SC	74	59	3	1	0	0	0	0
03-08-88	PPB	SC	0	0	3	0	0	0	0	0
10-08-88	PPB	SC	2	0	3	0	0	0	0	0
11-08-88	PPB	SC	0	0	1	0	0	0	0	0
16-08-88	PPB	ROV	0	0	0	0	0	0	0	0
18-08-88	PPB	ROV	0	0	0	0	0	0	0	0
22-08-88	PPB	ROV	0	0	0	0	0	0	0	0
06-09-88	PPB	ROV	0	0	0	0	0	0	0	0
12-09-88	PPB	ROV	0	0	0	0	0	0	0	0
14-09-88	FB	ROV	0	0	4	1(dead)	0	0	0	0
15-09-88	FB	ROV	0	0	8	0	0	0	0	0
21-09-88	FB	ROV	13	16	59	0	0	123	0	1
23-09-88	FB	ROV	0	0	17	0	0	47	0	0
28-09-88	PPB	ROV	0	0	0	0	0	0	0	0
06-10-88	PPB	ROV	0	0	1	2	0	0	10	1

Glizzard Shad/Drum

APPENDIX 2

Advantages and Disadvantages of Methods Evaluated

Advantage of the ROV Submersible

Diving crew is not required for operation.

Can be used at depths greater than 12 m where divers are restricted, as in the intake tunnel exit.

Has a longer bottom surveillance time than divers.

Can be used with a smaller crew number and crew does not have to be a diver.

Provides a video record on VHS tape. Information may be quantified and described.

Can be used in a stationary position or moved about.

Less likely to disturb or frighten fish than divers, although this is not conclusive owing to the absence of schools of alewife around the intake during testing of the ROV.

Disadvantages

Water clarity should be at least 2 m.

Moderate amount of skill required depending on the working environment for the ROV.

Maneuverability is limited to currents less than 2.5 kts (1.3 m/s) for this model of ROV.

View of the environment is limited by camera angle.

Light level must be 500 lux or greater. Artificial lighting is required in absence of of sunlight.

Dependability of the "Seawhip" is questionable. Manufacturer is out of business.

A replacement model may be necessary. Capital cost is moderately high.

Possible disturbance to fish and/or influence of behaviour.

Debris and obstructions can entangle the cable or snag the vehicle.

APPENDIX 2 (cont'd)

Advantages and Disadvantages of Methods Evaluated

Advantages of the Stationary Video Camera

Can monitor for an extended duration with minimal attention.

Least affect on fish behaviour; no startle response or fear is generated.

Disadvantages

Fixed in one position.

Very limited view and depth of field.
Dependent upon fish passing in from of the camera.

Focus and contrast is not sharp and a subject must be close to the camera.

Requires a dive team to orient the housing and secure it to intake structure. Useful depth is limited to diver's restrictions.

Video is limited by available light and turbidity. Artificial lighting may improve quality but may also influence fish behaviour.

APPENDIX 2 (cont'd)

Advantages and Disadvantages of Methods Evaluated

Advantages of the Diver & Camcorder

Widest area of view and better orientation to landmarks and positioning.

Diver is more observant and can record a wider choice of subject material.

Diver is more sensitive to the environment, eg. currents.

Diver has sharper focus.

The diver being present at the same time of the video record can supplement the video data with his own observations.

Disadvantages

Recording can only be made with the diver present; usually less than one hour.

Camera focus is not sharp; however, information can be clarified with the diver's notes.

Use of the camera requires practice; the diver must hold the camera steady and pan slowly.

Note: Better cameras are now available with lower light sensitivity, sharper focus higher resolution and zoom features.

Camera use is limited to the diver's depth (12 m) safety restriction.

Divers are not permitted in the forebay and use on the intake surface may be restricted at later dates under full plant operation.

Influence fish behaviour; the diver's presence and bubbles may frighten fish.

Video is limited by available light and turbidity. Artificial lighting may improve quality but may also influence fish behaviour.

APPENDIX 2 (cont'd)

Advantages and Disadvantages of Methods Evaluated

Advantages of the Scanning Sonar

Qualitatively useful in providing directional movement of fish.

Can detect fish under turbid conditions during daylight or darkness.

Sonar may be useful in the forebay as the station becomes operational and submersibles may not be used.

Monitoring is least dependent upon weather factors provided air bubbles are not entrained due to surface vortices. In this event, air bubbles may be detected as targets.

A high resolution sonar system has a major advantage over other systems by means of extended periods of data collection. Fish diel and seasonal activity in the vicinity of the intake may be better understood.

Data acquisition and transfer from a remote location is possible.

Disadvantages

Limited by pulse beam-width (7°).

Limited use due to shallow depth and small working area.

Cannot easily count or identify the targets.

Scan trace is dimly lit and not easily videotaped. May be possible to interface with a qualitative system.

Wesmar SS 150 is an outdated system, virtually obsolete and difficult to service.

Requires divers to install and remove the transducer.

High resolution sonar carries considerable developmental time and capital cost. However, this may offset expensive, more labour-intensive methods.